Exclusive Production of Baryon Resonances Using $^1H(e,e'p)X$ *Update*

Experiment 01-002 at Jefferson Lab in Hall C

A.N. Villano[1]

villaa@jlab.org

[1]Rensselaer Polytechnic Institute

For the Hall C Baryon Collaboration

Institutions (Full Listing)

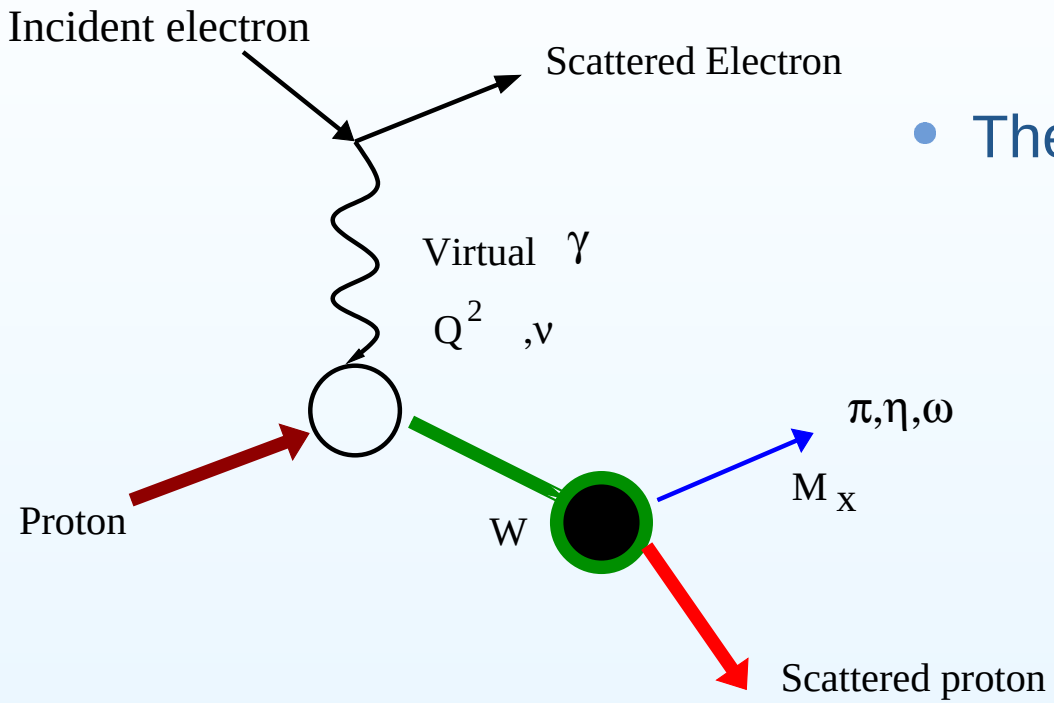
Spring 03 Collaboration

Argonne Nat. Lab., Bucharest, Univ. of Colorado, Duke Univ., Florida Int. Univ., George Washington Univ., Hampton Univ., Jefferson Lab, Mississippi State Univ., Univ. North Carolina A & T, NIKHEF, Rensselaer Polytechnic Institute, Univ. of Regina, Univ. of Massachusetts, Univ. North Carolina at Wilmington, Univ. of Virginia, Yerevan Physics Institute, Ohio Univ., Univ. of the Witwatersrand, Univ. of Houston

Goals of the Experiment

- Baryon resonances $\Delta(1232)$ and S_{11} studied to extract transition amplitudes for exclusiv π^0, η, ω production
- Differential cross sections extracted and used to determine multipole transition amplitide at larger value of Q^2 than previously achieved
- Transition to pQCD will be studied through the Q^2 dependence of the quantity $E2/M1$ o the Δ (should approach unity in pQCD)
- W range of the experiment is expanded since the last installment in 1997 (experiment 97-101)
- Transition form factors extracted for $\Delta(1232)$ and S_{11} at the highest Q^2 thus far

Electro-production Process



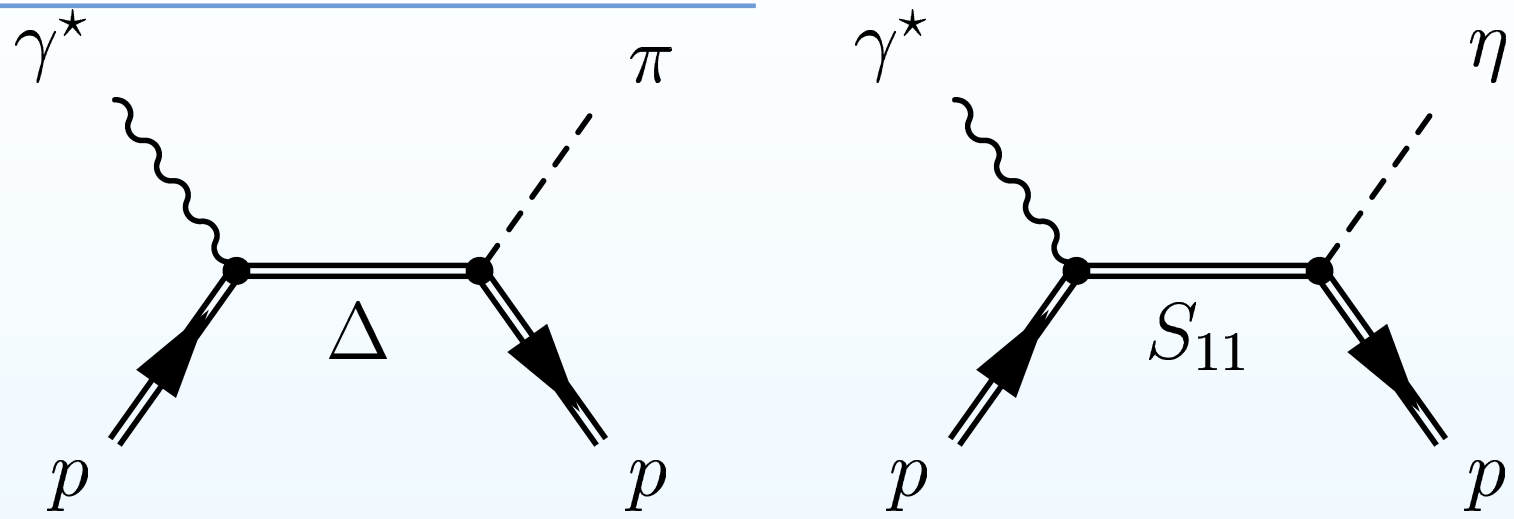
- The reactions for this analysis are:

$$\gamma^{\star} + p \rightarrow (N^{\star}, \Delta) \rightarrow p + \pi^{0}$$

$$p + \eta$$

$$p + \omega$$

Resonance Production (Δ,S_{11})

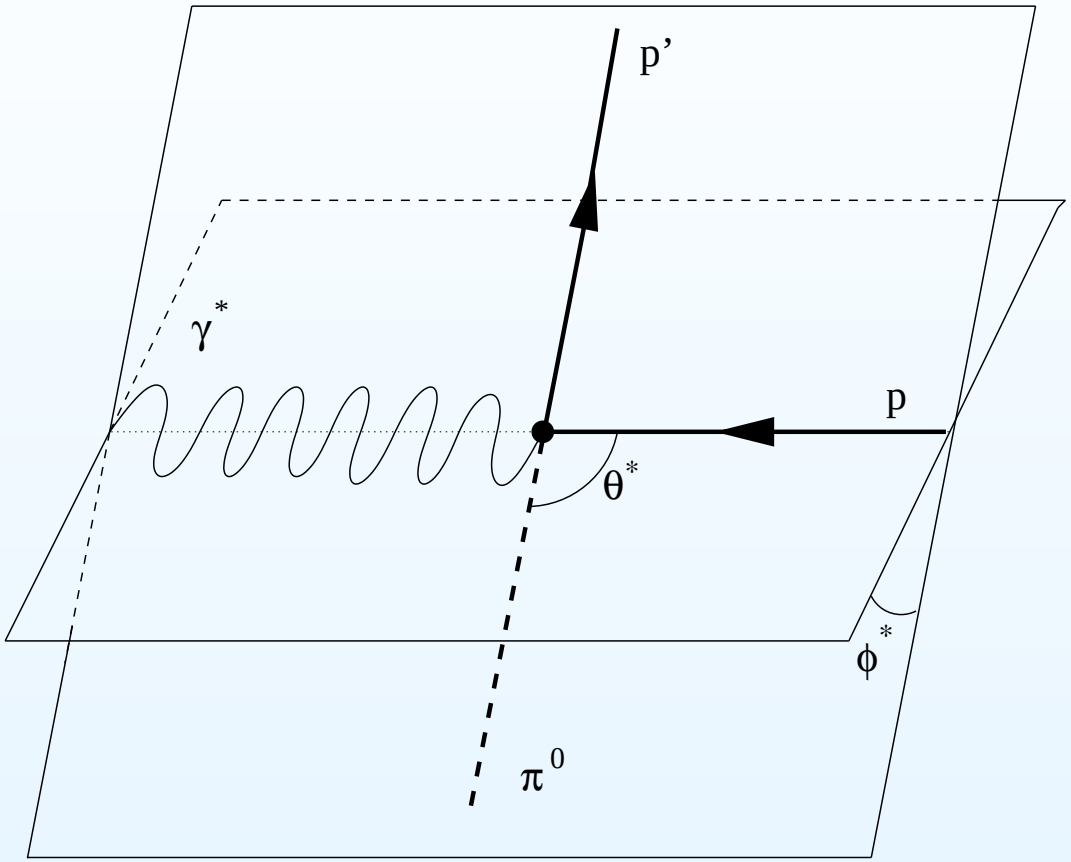


- Restriction to Δ, S_{11} decreases the number of independent functions to three
- Functions can be represented:
  $G^{\pm,0} = \frac{1}{2M}\langle(\Delta, S_{11}), \lambda_{res}|\epsilon_\mu^{\pm,0} J^\mu_{had}|P, \lambda_p = \pm\frac{1}{2}\rangle$

Multipole Definition

- For strictly pseudoscalar meson production one can expand matrix element according to total angular momentum, i.e. :
  $\langle N\pi|\vec{J}_{had}|N\rangle =$
  $\left(\chi^{\dagger}\vec{\sigma}\chi\right)\sum_{l\geq 0}\left[\left(lM_{l+}+E_{l+}\right)P'_{l+1}+\left((l+1)M_{l-}+E_{l-}\right)P'_{l-1}\right]\cdots$
- Considering only Δ production reduces the number of multipoles
  $A_{\frac{1}{2}} \propto G^{+}$
  $A_{\frac{3}{2}} \propto G^{-}$
  $C_{\frac{1}{2}} \propto G^{0}$
- Also These can be related (through $E_{l\pm}$ and $M_{l\pm}$) to E2 and M1:
  $A_{\frac{1}{2}} = -\frac{1}{2}(M1+3E2)$
  $A_{\frac{3}{2}} = \frac{\sqrt{3}}{2}(E2-M1)$
  $C_{\frac{1}{2}} = -S2$

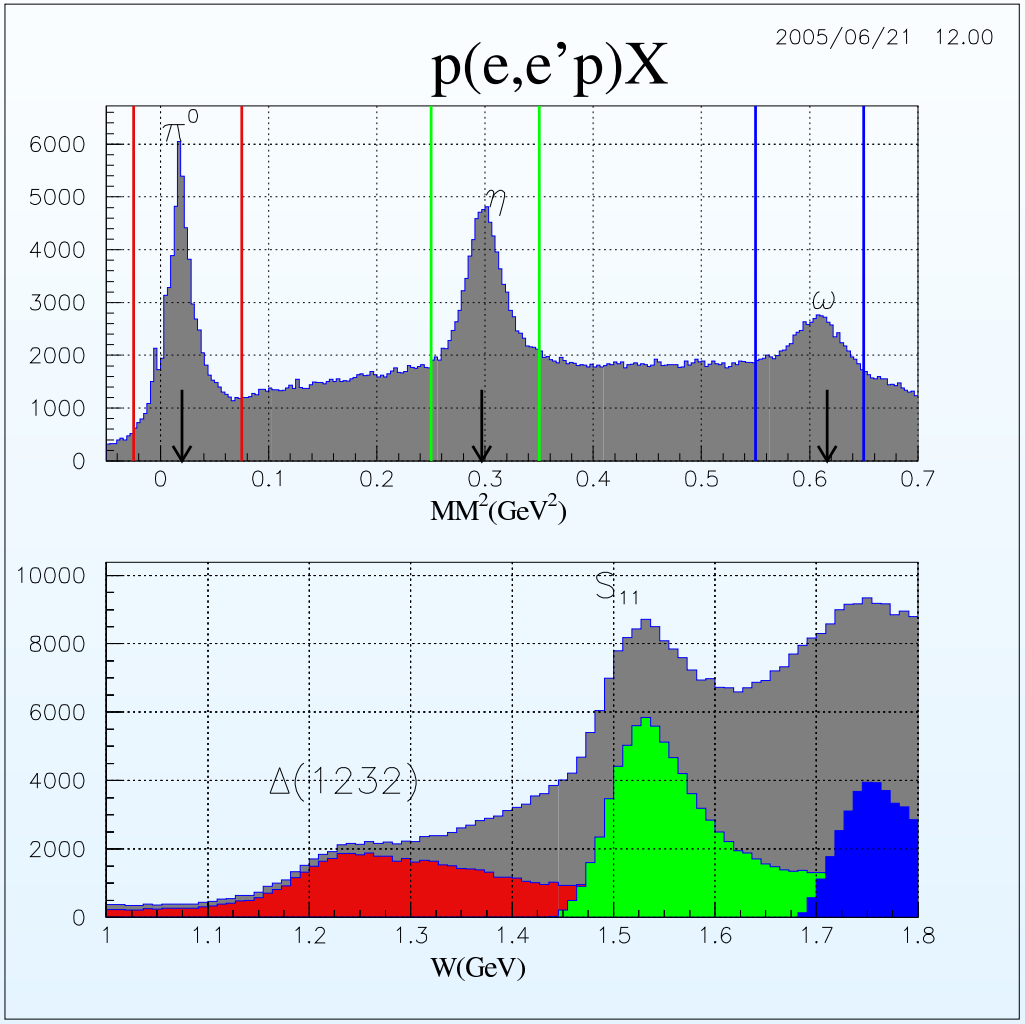
Kinematic Variables



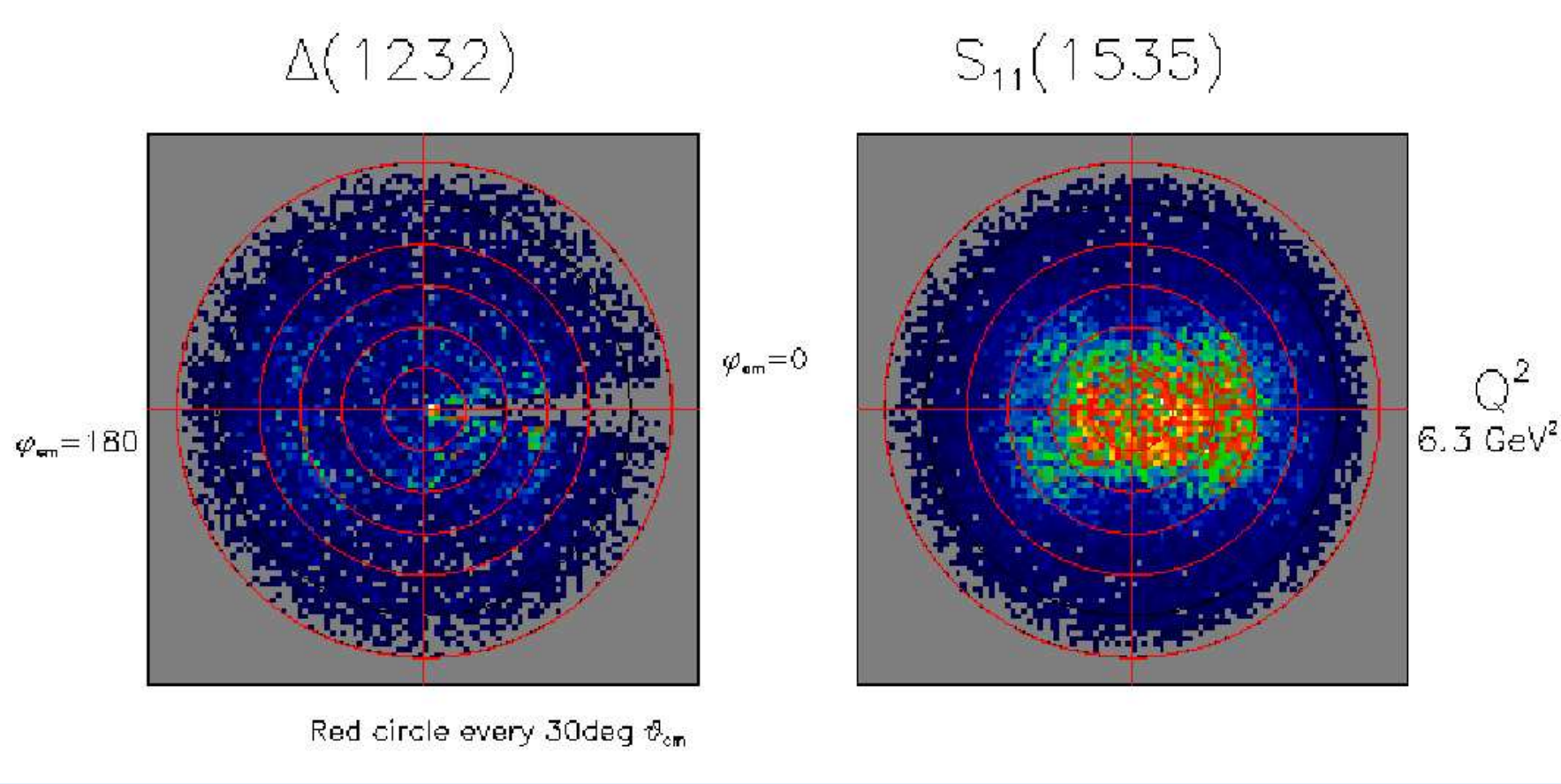
- Virtual photoproduction kinematics

Exclusive Studies

- The M_x^2 peaks can be used to constrain the reaction and/or baryon resonance
- The M_x^2 resolution for the π^0 allows detailed study of the reaction ${}^1H(e,e'p)\pi^0$
- Exclusive cross sections and amplitudes will be compared to models and previous data



Angular Coverage

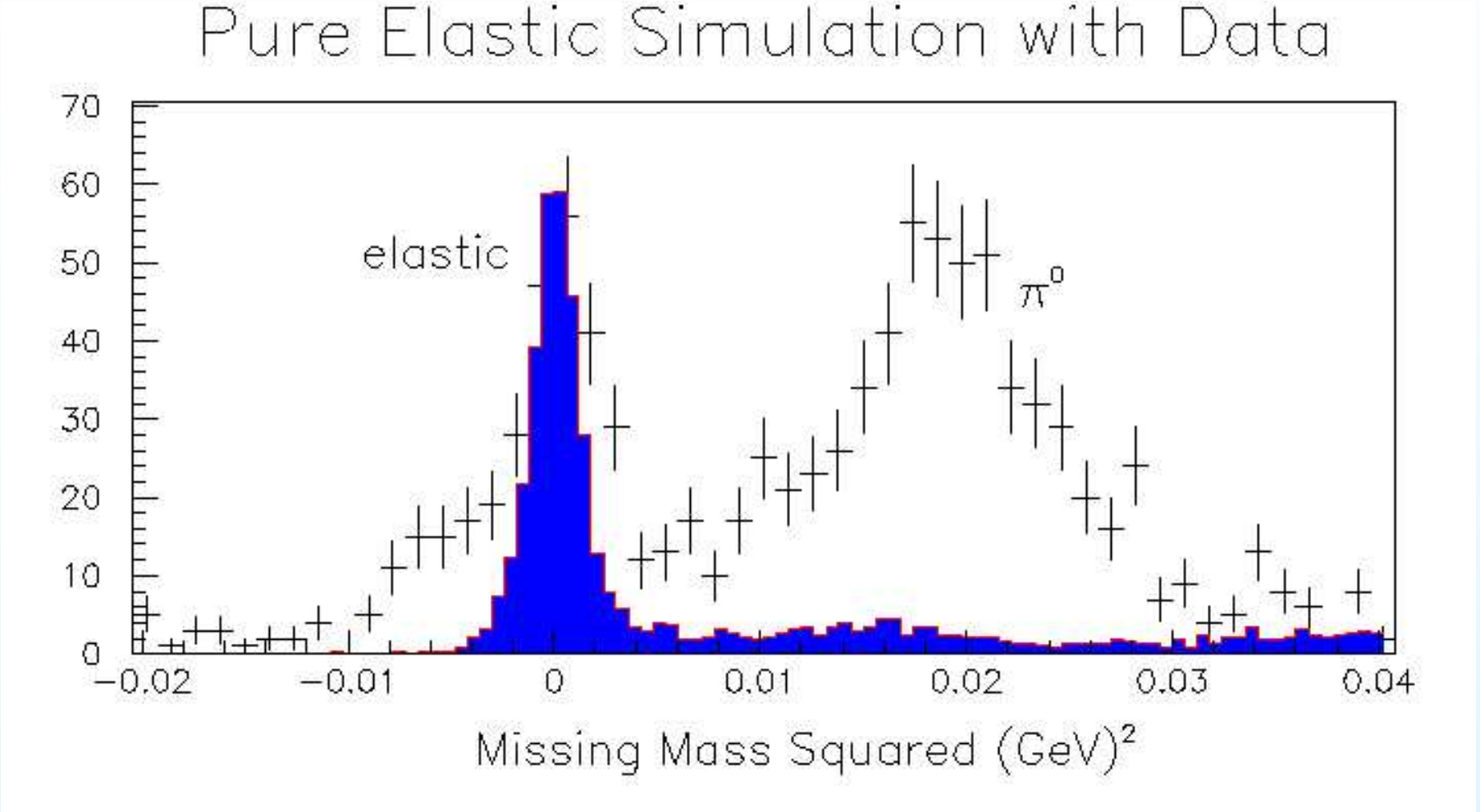


- Full angular coverage for both $\Delta(1232)$ and $S_{11}(1535)$ at low Q^2 point
  - $x = \theta^{\star} cos(\phi^{\star}) \quad ; \quad y = \theta^{\star} sin(\phi^{\star})$

Differential Cross Section Extraction

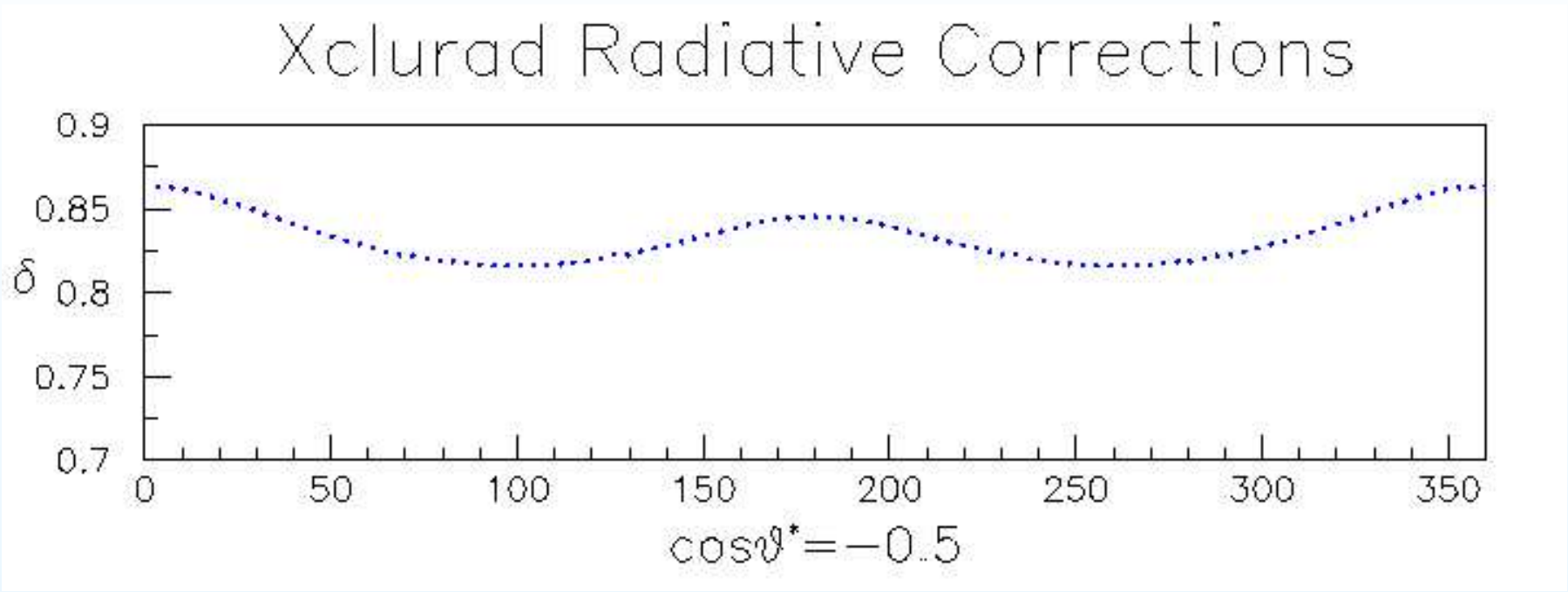
- Background Subtraction
  - Fit method with simulated distributions
- Acceptance Correction
  - Obtain acceptance as a function of kinematic variables via simulation (SIMC)
  - Extract the measurable cross section by correcting for acceptance
- Radiative Corrections
  - Use EXCLURAD to produce radiative correction factors
  - Extract measured cross section σ_{mes} from data
  - Apply factor and iterate

Elastic and Bethe-Heitler



- Can use fit to subtract background
- Is elastic resolution being predicted?

Radiative Corrections

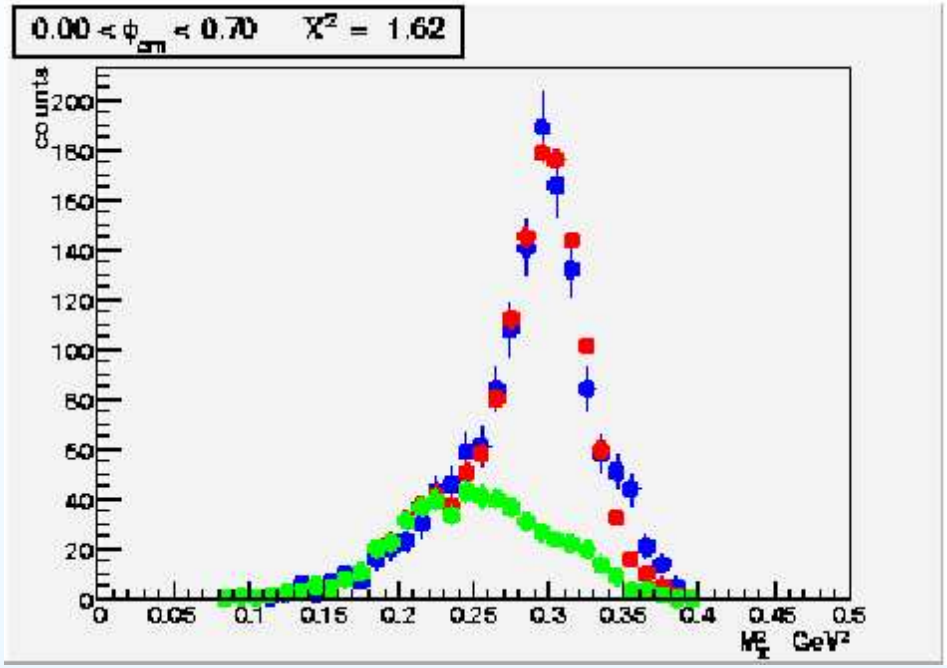


- Full radiative ratio δ determined by EXCLURAD

  $\frac{d\sigma_{mes}}{d\Omega} = \frac{d\sigma_0}{d\Omega} e^{\delta_e}(1+\delta_{had})$

- δ_e parameterizes factorizable QED correction
- $\delta = \frac{\sigma_{mes}}{\sigma_0}$

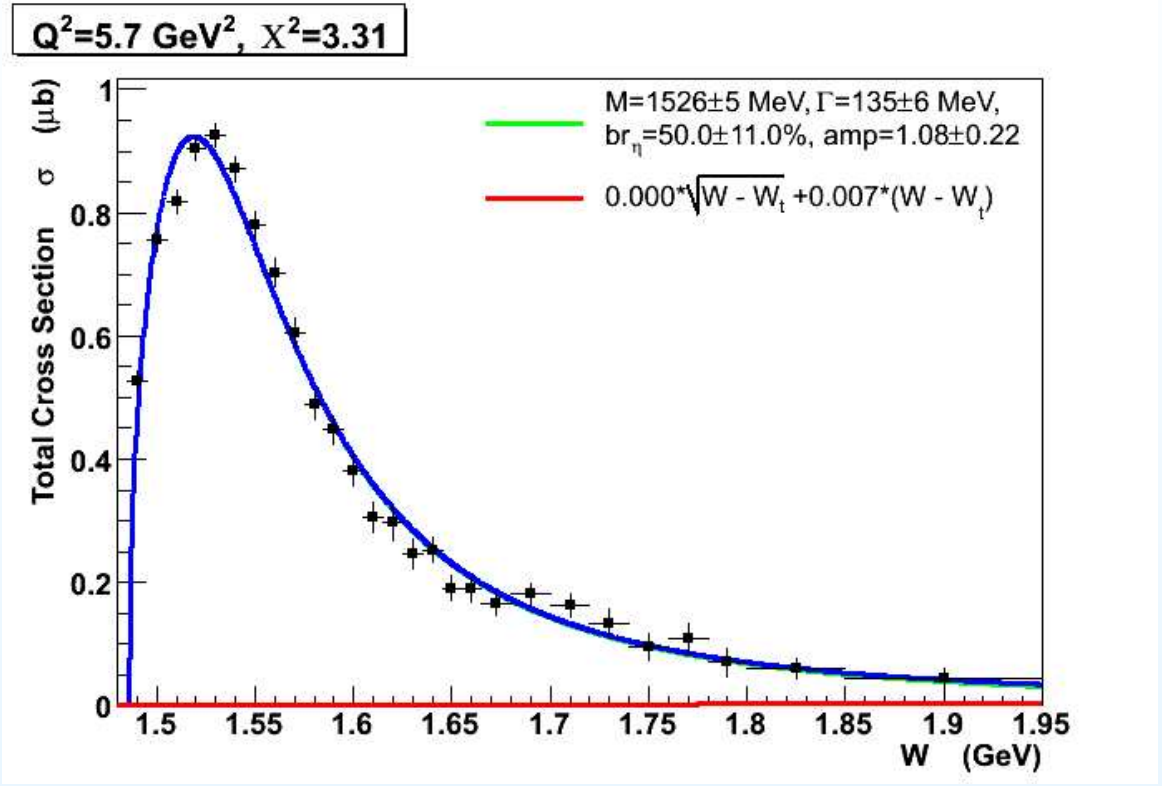
Two π Background



- Two π background model does well but cannot get overall absolute normalization
- Fit the simulated distributions to the overall data spectrum

Plots courtesy of M. Dalton

Total Eta Production Cross Section



- Reasonable fit to Breit-Wigner shape

Plots courtesy of M. Dalton

Tasks to Complete

- Corrected Differential Cross Section: March 07
  - Fit method with simulated distributions
  - Use EXCLURAD to radiative correct
  - Resolution studies to see how robust background suppression is
- Multipole Amplitudes: April 07
  - Extract W dependence of multipole amplitudes
- Systematic Errors: May-June 07
  - Adjust parameters of analysis to check for stability

Summary

- Beam energy of $5.5GeV$ with two Q^2 settings
  - Measure the cross sections for ${}^1H(e,e'p)X$, $X = \{\pi^0, \eta, \omega\}$
  - X identified by missing mass, M_x
  - Q^2 of 6.3 and $7.7GeV$ for Δ resonance
  - Varied proton arm angle and momentum to cover wide range of θ_{cm} and ϕ_{cm} bins for W up to $2GeV$
- Physics to extract
  - Plan to extract the $G_M^\star$, E_{1+}/M_{1+}, S_{1+}/M_{1+} for the Δ
  - Plan to extract $Q^3 A_{\frac{1}{2}}$ for the S_{11}
  - Study the transition from *soft* to *hard* physics as a function of Q^2
  - Constrain the t and x dependence of the GPD with elastic and transition form factors and wide angle Compton form factors
  - Can think about extracting $H(e,e'p)\omega$ and $H(e,e'\pi^+)N$ observables